Title: Metric Topological Relaxation (MTR): A Unified Origin of Mass, Dark Energy, and Vacuum Elasticity Limits

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Abstract
This paper proposes a model of the Universe as an elastic 4D continuum characterized by an intrinsic stiffness modulus $\epsilon_{max} \approx 10^{113}$ J/m³ at the Planck scale and an effective macroscopic tension $\epsilon_{vac} \approx 6 \cdot 10^{-10}$ J/m³. Matter is interpreted as a topological defect (knot) within this medium. We demonstrate that cosmic expansion is a phase transition process of "tension → volume," allowing the derivation of dark energy density from first principles and resolving the 122-order cosmological constant problem. A deterministic interpretation of the uncertainty principle is proposed as an inverse Hooke's law.

1. Introduction: The Metric Substrate

We postulate that the physical vacuum is an elastic substrate (metric continuum). Unlike classical General Relativity, where spacetime is a purely geometric background, the MTR model attributes physical characteristics to it: a modulus of elasticity and a yield strength.

2. The Mass-Volume Equivalence Equation

The central tenet of the theory is the invariance of energy during the transition from a localized state (particle) to a free metric:

$$mc^2 = \Delta V_{vac} \cdot \epsilon_{vac} = \Delta V_{lp} \cdot \epsilon_{max}$$

Where:
$\epsilon_{max} \approx 10^{113}$ Pa is the ultimate tensile at the Planck scale.
$\epsilon_{vac} \approx 6 \cdot 10^{-10}$ J/m³ is the background tension of the expanded Universe.
Matter (the knot) represents an ultra-dense concentrate of volume: the relaxation of a single proton generates ≈ 0.25 m³ of new space.

3. Resolving the Cosmological Constant Problem

The 122-order discrepancy between QFT predictions and observations is explained as a geometric relaxation of tension during expansion from Planck scales *lp* to the Hubble radius *LH*:

$$\rho_{obs} = \rho_{pl} \cdot (l_p / L_H)^2 \approx 10^{113} \cdot 10^{-122} \approx 6 \cdot 10^{-10} \text{ J/m}^3$$

Dark energy is thus the residual elastic "echo" of the primary phase transition.

4. The Nature of Matter and the "Halo Effect"

Elementary particles are the topological residue of the Big Bang—stable micro-knots that did not undergo full relaxation.

Dark Matter: An area of excess vacuum tension (an inertial wake) arises around each node (baryonic mass). This "halo" creates an additional centripetal acceleration $a_0 \approx 1.2 \cdot 10^{-10}$ m/s^2, eliminating the need for hypothetical particles.

5. Explaining Phenomenological Anomalies

- **JWST Anomalies**: Overmassive early galaxies formed due to the high density of primary knots during the active relaxation phase.
- **Hubble Tension**: Discrepancies in H_0 are caused by local variability of the ϵ_{vac} modulus in regions with differing matter density.
- **Quantum Mechanics**: The uncertainty principle is reinterpreted as the mechanical limit of medium deformation (Inverse Hooke's Law).

6. Falsifiability and Predictions

Variability of *c*: The speed of light $c = (\epsilon/\rho)^{1/2}$ should microscopically depend on local tension (testable via pulsars in lensing zones).
DM Detectors: Direct searches for dark matter particles (WIMPs) will yield null results.
BH Mass Degradation: Slower growth of SMBHs due to the conversion of captured mass into metric volume.

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